gray, micaceous sandstones characterize the next 300 to 350 feet. This red-shale interval constitutes the Cattaraugus formation. In its upper part a second lentil, the Salamanca conglomerate, occurs. It lenses out eastward, but becomes prominent westward in the Salamanca region and is regarded as the same as the Pope Hollow and Panama conglomerates farther west. A third lentil, called the Kilbuck conglomerate by Mr. M. L. Fuller, occurs about 50 to 70 feet above the Salamanca. It is found in the Salamanca region only.

The next formation is the Oswayo, characterized by rusty olive colored, limonitic sandy shale, from 160 to 250 feet thick. Over this the Sub-Olean, or Shenango, conglomerate is found in some areas, usually 20 to 30 feet thick, but apparently cut out in other places, and on the Olean quadrangle losing its conglomeratic character and merging into a sandy shale similar to the Oswayo shale. Over it, when not apparently cut out also, are 30 to 50 feet of Sub-Olean, or Shenango, shale. This is overlaid by the Olean conglomerate, usually massive and round-pebbled, 50 to 90 feet thick. A few feet of thin, rusty, sandy Sharon shale overlies the Olean conglomerate at Rock City.

The shales below the Wolf Creek are Devonian. From the base of the Wolf Creek to the top of the Oswayo a mingling of Devonian and Carboniferous faunas makes it best to designate these rocks, for the present, as Devono-Carboniferous. Above the Oswayo the rocks are regarded as Carboniferous.

The rocks dip 25 to 30 feet per mile slightly west of south. Minor rolls causing local reversals of dip are known to occur.

AUTHOR'S ABSTRACTS OF PAPERS READ AT THE WASHINGTON MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. SECTION E.

Geological Age of the West Indian Volcanic Formations. By J. W. SPENCER.

THE Greater Antilles appear to be nearly devoid of volcanoes. The writer has seen only the remains of one in Jamaica (at Low Layton), and none in Cuba. But there are extensive underlying igneous formations in all these islands. However, in the inner zone of the Caribbean or Windward Islands there are many cones, and beneath these and the outer islands there is an underlying volcanic basement. In such of the outer islands as St. Martin, and better still in Antigua, and in St. Croix one gets some knowledge of the antiquity of the

older eruptive formations. In Guadeloupe the geological records are equally well preserved, on one side, while on the other there are the more recent volcanic cones, which can also be seen in St. Kitts, Statia, Dominica, Martinique, St. Lucia, St. Vincent, etc.

In St. Martin and Antigua the old volcanic basement forms mountains still uncovered by modern cones, as also in St. Croix. The rocks are essentially an andesite in form of both lavas and tuffs. Their surface topography is molded by atmospheric agents into low mountains and valleys. Overlying such a basement in St. Croix and St. Thomas, according to Cleve,[1] there is a conglomerate containing pebbles with Cretaceous fossils. In this region these basement rocks are so dissected that their remains constitute many of the islands of the Virgin group.

But in Antigua and Grande Terre of Guadeloupe the strata overlying the denuded igneous basement is a subaqueous redistributed tuff with some calcareous beds in the upper zone, over which rest conformably the white limestones, a marly deposit containing Oligocene corals and shells.[2] South of the Guadeloupe Archipelago and Monserrat, the outer islands disappear, and the writer is not aware of the occurrence of the early Tertiary limestones remaining so as to leave evidence of the age of the igneous basement, though by its lithological characteristics and the physical features of its ancient surface one can hardly be far astray in concluding that they are of the same age as the similar formations on the islands to the north. In Barbadoes the Oligocene limestones reappear, but here there are no igneous deposits. It thus seems that the whole Caribbean plateau beneath both the volcanic ridges and the limestone islands is underlaid by an igneous formation dating back to the commencement of the Tertiary periods at least, if indeed these rocks are not as old as those of St. Croix, that is, as ancient as the Cretaceous period.

In St. Martin, St. Bartholomew, and Antigua the mountain belts are entirely made up of the denuded rocks of this old igneous formation without a covering mantle. So also, part of Statia, St. Kitts, Monserrat, the southern end of Martinique, portions of St. Lucia, and the southern end of St. Vincent have their surfaces molded out of the ancient igneous accumulations; but elsewhere in these islands, as also

[1] "On the Geology of the Northeastern West India Islands," *Trans. Roy. Swedish Acad. Sc.*, Vol. IX., 1870–71.

[2] See "Geological and Physical Development of the Various Windward Islands," six papers by J. W. SPENCER, in *Quar. Jour. Geol. Soc. Lond.*, Vol. LVII (1901), pp. 409–543, and Vol. LVIII (1902), pp. 341–65.

in Guadeloupe proper and Dominica, they are covered with volcanic materials which constitute more or less of the cones and ridges, rising to a height of 3,000 to 4,000 feet. In these mountainous islands there is not merely a combination of late and ancient eruptive deposits, but there are several formations secondarily derived from the remains of the older basement, and here is room for more study than has been attempted.

The history of one is more or less the history of all of these conical islands. For instance, in Dominica there is the old andesitic rock, overlaid by volcanic breccia or conglomerate. At other points the age of the tuffs cannot at present be assigned, but some of them have been denuded into relatively large valleys, which have been partly refilled with still newer tuff (like that of the Roseau valley), containing an abundance of water-worn pebbles, often arranged in lines among the more angular material. Such may correspond to the early Tertiary subaqueous tufaceous beds of Grand Terre (Guadeloupe). And these beds have been subsequently tilted outward at considerable angles. As in St. Martin and Antigua and Grand Terre, there is nothing to show that there were any mid-Tertiary eruptions when the whole region was somewhat elevated and the denuding agents were molding the surface into rounded outlines. From the corresponding topography in the more volcanic islands, where not surmounted by the modern cones, the impression is left that the volcanic activity of the region was quiescent during much of the Miocene-Pliocene period, before the building up of the cones and ridges, which were constructed at a relatively late date, for we find the sea bed elevated along with these ridges. Thus we find in Statia and in St. Kitts volcanic cones raised by an upward thrust which carried along with it the sea-floor, covered by about thirty feet of marl now forming broken mantles surrounding the cones to elevations of from 400 to 900 feet. Elsewhere, however, we find fragments of a similar formation appearing with the volcanic rocks brought up by a general elevation of the island. These limestone marls contain practically a living fauna, thus showing the elevation to date no farther back than the end of the Pliocene period. Again, there are two series of gravel formations, one of which is older than the coralline strata just mentioned as interbedded with the volcanic ejectamenta; but this gravel formation had its surface greatly denuded before the formation of the marl. Again, both the marl and the gravel have been further subjected to erosion so as to be often left only in broken series. The newer gravel has not been subjected to so

much denudation. The youthful lavas have been seen both in Dominica and St. Kitts beneath the stratified gravel beds, but at present it has not been determined whether they belong to the older or newer series. The lower gravels in their succession correspond in position to the Lafayette of the continent, and the upper gravels to that of the Columbia. The eruption which raised the cones in St. Kitts and Statia, above referred to, appears to have occurred during the subsidence which gave rise to the upper gravels provisionally regarded as the equivalent of the Columbia series — a mid-Pleistocene formation — and the marl beds thus raised rest upon an incoherent bed of volcanic ashes, containing a living fauna. From all facts before the writer it seems that the volcanic ridges owe their origin to volcanic activity which recommenced about the close of the Pliocene period, and that the eruptions have continued with more or less interruption down to the present day; for we find that the cones and ridges have not become so deeply dissected by rains and streams as would be expected, had their growth not been continued more or less continuously from their rebirth at the close of the Pliocene period to the present year of recorded activity.

The Marl-Loess of the Lower Wabash Valley. By M. L. FULLER AND F. G. CLAPP.

THE fine silts bordering the Wabash valley have in the past been correlated with the ordinary loess of the region by many geologists, including Owen, Collett, Wright, Chamberlin, Salisbury, and Leverett. The recent field work of the writers brought out many points of difference in the silts lying respectively above and below the 500-foot contour. The lower type, which we have termed "marl-loess," is coarse and frequently carries as high as 30 per cent. of $CaCO_3$, while the common or upland type carries less than 5 per cent. Numerous exposures of distinctly stratified silts, interbedded in a few instances with pebble layers, were noted. Fossils consisting mainly of land species abound, but are not in general regarded as indigenous, as the perfection of the laminæ in the fossil-bearing layers points to an absence of vegetation during its accumulation, and would indicate — if the deposit were eolian — the probable absence of both moisture and food, the two chief requisites of the molluscan life. Instead of forming a mantle conforming to surface inequalities, as does the upland loess, the marl-loess frequently occurs as extensive flats or broad, gently sloping terraces, usually burying a somewhat rugged

topography. Fossils, stratification, terraces, and silted divides occur at all altitudes below 500 feet, but never above, and although the greater abundance of the marl-loess on the east side of the valley is suggestive of eolian action, the character and range of the features mentioned afford a preponderance of evidence in favor of an aqueous origin of the deposit up to an altitude of 500 feet, or 120 feet above the river. The upland loess is regarded as an eolian derivative of the marl-loess.

The Hanging Valleys of Georgetown, Colo. By W. O. CROSBY.

THE paper describes chiefly the break of several hundred feet between the floor of the valley of Clear Creek and that of one of its principal tributaries, Leavenworth Creek, and explains it as due, not to fluvial or glacial erosion, but to faulting, of which abundant independent evidence is afforded by mining developments. Other and similar features in the vicinity are correlated with this, and it is shown that the part of the main valley occupied by Georgetown is a depressed fault block or *graben*, and that the valley is due, in part, to displacement, and not solely to erosion, suggesting comparison with Yosemite. The idea is also advanced that the elevation of this part of the Colorado Range has been recently, and may be still, in progress, and that, while in the past the movement has been chiefly massive, developing the great fault scarp overlooking the plains, it has, in later time, affected the axis more than the margin of the great orographic block, leading to a marked tilting of the Cretaceous peneplain, and, in part at least, it is very locally differential, and, in the Georgetown instance, in a way to accentuate the topography.

Glacial Features of Lower Michigan. By FRANK LEVERETT.

THIS paper presents results of an investigation of the Pleistocene deposits and features of Michigan carried on for the past three years under the supervision of Professor T. C. Chamberlin, chief of the glacial division of the United States Geological Survey.

Lower Michigan lies within the limits of the latest or Wisconsin drift sheet, but inequalities of earlier drift sheets may have given rise to some of the topographic features and possibly to the strong features, such as basins and the high bordering rims. The high country northwest of the Saginaw basin has 350 to 500 feet or more of drift, while the basin itself has an average of scarcely 100 feet. It seems

doubtful if this difference, with its resulting relief, should be referred wholly to the Wisconsin or last stage of glaciation.

Evidence of distinct ice invasions is found in the northernmost part of the lower peninsula in the constituents of the drift, which are such as to show a movement east of south from the Lake Superior region into the Huron basin, another and probably later movement from the Georgian Bay region southwestward across Michigan and onward to southeastern Iowa, as well as the still later movement referable to the Wisconsin stage of glaciation. A single hill north of the Saginaw basin was found to carry Potsdam sandstone from the Lake Superior region, jasper conglomerate from the Georgian Bay region, and gypsum from the borders of the Saginaw basin. In the western and southern parts of the peninsula, interglacial soils and peat beds are struck in wells, while in the southeastern part striæ, as noted by Sherzer, suggest distinct ice invasions.

The paper discusses the lobing of the Wisconsin ice sheet, the development of a succession of moraines, and the lines of discharge for glacial waters. Attention is also given to drumlins which occur near Charlevoix, and to the eskers in the region covered by the Saginaw lobe.

The drumlins seem to be subglacial accumulations, since they consist of till which is more thoroughly kneaded or worked over than the till of the neighboring moraines. They appear also to have been built up slowly as the ice moved over them, there being traces of lamination concentric with the upper surface of the drumlin. The ice then apparently extended to a strong moraine that passes along the southeast border of the drumlin area.

The eskers of this region are commonly found in shallow valleys, termed "esker troughs," which were cut in the till. This situation, together with the fact that the eskers, like the till, are composed largely of local rocks, strongly favors the view that their material was derived from the till through the agency of subglacial waters.

On the Evidence of Post-Newark Normal Faulting in the Crystalline Rocks of Southwestern New England. By WILLIAM H. HOBBS.

STRUCTURAL work within the belt of crystalline schists of southwestern New England has until recently been carried out upon the assumption that the rocks have been deformed solely by a process of folding. Both Dana and Pumpelly have emphasized this assumption

in their papers upon the geology of the region. The effect of this assumption has been far-reaching and has profoundly affected the mapping during the past twenty years, so that faults have in but few instances been entered upon the maps. The study by the writer in the summer of 1899 of the complexly faulted basin of Newark rocks lying within the Pomperaug valley in Connecticut, and the consideration of the work of others upon the Newark areas to the east and to the southwest of the New England crystalline belt, led inevitably to the conclusion that a system of joints and faults produced in post-Newark time must have been superimposed upon the earlier structures produced by folding, and perhaps by faulting also, within the intermediate belt of crystalline rocks. The problem was then to find means of recognizing these faults within the complexly deformed province. The methods which have been found available are dependent, not so much upon the location of individual faults by the ordinary means, though such methods have not been overlooked, but by the reading of the fault *system* as a whole through the study of the topography, drainage, known formation boundaries, joint system, etc. Five small and widely separated areas were selected in the crystalline belt within each of which a considerable number of formations were found in small masses in juxtaposition. The structure of these areas, while difficult to determine, was found in each case to require only patience and industry, whereas the areas in which formations were found in larger masses by their very simplicity of areal distribution generally allowed several equally adequate explanations.

Briefly to summarize, it may be stated that in all of the areas a system of joints in correspondence with a system of faults was found superimposed upon the older folded structures of the region. The relative importance of deformation by folding and by faulting within the region in question is somewhat difficult to estimate, but it seems probable that the present attitudes of the rocks are at least as largely to be accounted for by the fault structure as by the system of folds.

On a Record of Post-Newark Depression and Subsequent Elevation Preserved in the Crystalline Rocks of New England. By WILLIAM H. HOBBS.

ALONG the course of the Housatonic river, between the townships of Sheffield, Mass., and Salisbury, Conn., is found a somewhat remarkable belt of largely silicified dolomite whose length is not

far from twelve miles and whose breadth varies from a half mile to two miles or more. This somewhat remarkable backbone of rock early attracted the attention of Percival. It is noteworthy for its hummocky structure, but it nowhere rises more than one hundred feet above the general level. Careful study shows that the skeleton-work of silica forms an intricate network which goes out from parallel vertical walls of considerable thickness. These trunk lines or feeders are shown to have the direction of parallel series of vertical joints which had their origin in post-Newark time and were unquestionably conditioned by a compression of the southwestern New England region as a whole. The width of the silica walls forming the feeders and the peculiarities of the silica network lead to the belief that the same process of solution and removal of the dolomite which is now widening joint planes in the area, operated subsequent to the formation of the joint planes and previous to the infiltration of the silica. If it be true that surface conditions operated to widen joint fissures, we must assume a depression of the area until this surface zone came within the belt of cementation, for here only could the infiltration of the silica have obtained, and thus a cycle of depression and elevation of the area within post-Newark times must be supposed.

The Freshwater Tertiaries of Green River, Wyoming. By W. M. DAVIS.

A BRIEF visit to the Tertiary formation of Green River, Wyoming, in the summer of 1902, sufficed to discover many variations of texture in the strata that have usually been regarded as lacustrine. Fine bedded cardboard shales frequently alternate with sandy layers in which cross-bedding and ripple-marks are not uncommon; some of the strata contain small clayey pebbles cemented by calcareous material, and closely resembling certain specimens of "tepetate" brought from Mexico by R. T. Hill. It is believed that so great a variation of texture is inconsistent with the generally accepted theory that the Green River formation was deposited in a large and deep lake. The deposits are better accounted for by deposition in a variable shallow lake. possibly alternating from time to time with subaërial or fluviatile conditions.

The Basin Ranges of Utah and Nevada. By W. M. DAVIS.

SEVERAL mountain ranges in the Great Basin of Utah and Nevada, examined in the summer of 1902, are believed to be faulted blocks,

progressively displaced from late Tertiary to the present time, and maturely carved by contemporaneous erosion. The evidence for this conclusion is not structural, but physiographic. The base line of the ranges is of gentle curvature, unrelated to the mountain structure. The ravines by which the ranges are often dissected are narrow and steep-walled to their very mouths. The spurs between the ravines are often truncated systematically in a triangular facet at the mountain base. All these features are necessary results of progressive faulting and contemporary erosion, while they are not explainable on the theory that the ranges are residuals of much larger masses, unrelated to faulting.

The Blue Ridge in Southern Virginia and North Carolina. By W. M. DAVIS.

A RECENT visit to southern Virginia and North Carolina brought clearly to my attention what many students of that region must know already, but what is certainly unknown to geographers in general, namely, that the Blue Ridge is there not a ridge in any proper sense of the word, but a southeast facing escarpment. The escarpment is not due to any persistent rock structure, but results from the reduction of the land surface to a relatively low level by the headwaters of the short Atlantic rivers, whose drainage area therefore underlies that of the larger west-flowing rivers of the Mississippi system. The escarpment occurs where the Atlantic streams are undercutting the uplands of the Mississippi system. Residual mountains rise over the rolling uplands of the Atlantic rivers and over the rolling highlands of the Mississippi river: Kings and Pilot mountains are examples of the first, and Mount Mitchell and Roan mountain of the second. Grandfather mountain stands on the escarpment.

The Protection of Terraces in the Upper Connecticut Valley. By C. H. HITCHCOCK.

THE conclusions derived after many years of study relative to the origin of the Connecticut river terraces north of Massachusetts are as follows: (1) The higher terraces are part of a flood-plain deposited by the waters derived from the melting of the ice-sheet. (2) A differential depression of level amounting to about one and one-fourth feet to the mile in proceeding northerly greatly diminished the velocity of the current, so that the material is much finer than it would have been

had the southerly slope been the same as now. For example, at the Wells river, Vermont, the altitude of the river is now 407 feet above tide; but anciently it was 356 feet. The highest terrace is now 630 feet; formerly it is estimated to have been 373 feet, a fall of 257 feet. The reduction of the descent was from 2 to 1.4 feet to the mile. (3) The carving of the greater terraces was effected while the land was resuming its present level — probably lower than its original altitude. (4) The lower terraces and the intervals were formed later.

The following features were not clearly understood: (1) Why should the terraces upon the opposite sides of the valley commonly vary in numbers, altitude, and bulk? (2) Why are the deltas of the tributaries so often higher than the normal flood plain? (3) Why should the number of the terraces of the tributaries so often exceed those of the main stream, their upper surfaces being the same? These queries may be answered partly by assuming that the flood plain was not entirely filled out and that the tributary may often have had an extraordinary volume, bringing down a disproportionate amount of sediment. But there remained this problem: Why is there such a great irregularity in the altitudes and number of the lower terraces?

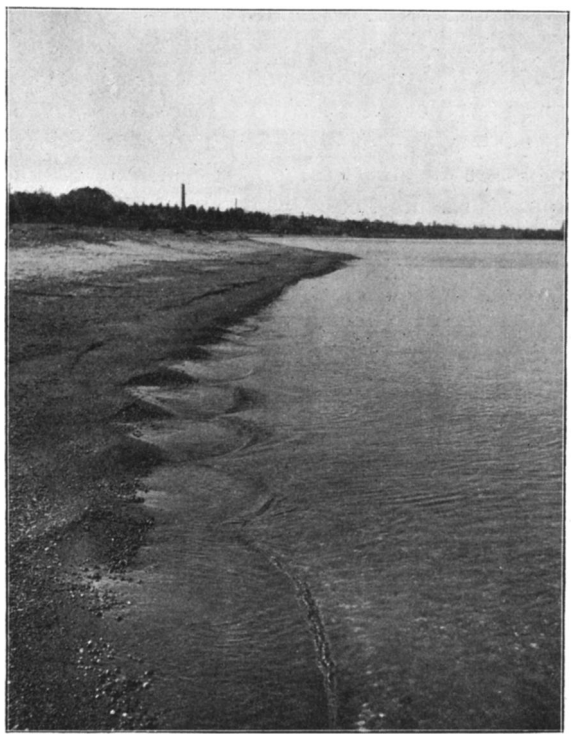
A better understanding of this subject has been afforded by the recent paper of Professor W. M. Davis,[1] who applies to the solution of the problem the theory of Hugh Miller the younger. Miller recognizes a slow regional uplift while the river wears away the accumulated sediment, and ascribes the presence of each lower terrace to a species of protection afforded by such obstacles as ledges and till, as the degrading river swings laterally to lower and lower levels. At the Westfield locality the presence and altitude of every terrace are clearly shown to be due to this cause. The simplicity of this explanation causes one to wonder why it had not been understood earlier. I have applied it extensively the past season to the modified drift of the upper Connecticut and adjacent streams and found it very generally acceptable; in fact, its well-nigh universal adaptation became quite monotonous. Diagrams were prepared to show how the terraces had been protected over an area fifteen miles long in the neighborhood of White River Junction and Hanover. The villages of Hartford, Wilder, and Hanover occupy such protected situations. Between East Hartford and Wilder an esker with underlying stiff clays has assisted in the preservation of the ancient flood plain. In Haverhill, thirty miles northerly, the absence

[1] "The Terraces of the Westfield River, Massachusetts," *American Journal of Science*, Vol. XIV (August, 1902).

of protection seems to have led to the extensive scouring out of the valley, and for that reason the interval is unusually broad. Elsewhere it was observed that tributary streams have cut across the higher terraces, whose exposed scarps remain in spite of the absence of any protecting underlying ledges.

Shore Phenomena on Lake Huron. By M. S. W. JEFFERSON.

KINCARDINE, Ontario, is nearly one hundred miles north of Port Huron, on the east shore of Lake Huron. As the shores there are



BEACH CUSPS IN LAKE HURON.

undergoing uplift, there is an interesting contrast with geographic conditions south of Gilbert's isobase, as at Muskegon, Lake Michigan. There a line of dunes margins the "Big Lake," standing on a bar which almost closes the river mouth, that expands behind into a considerable lake, and is marshy, with typical drowned-character for

miles back. At Kincardine and similar points the bar and ancient lagoon behind it are now high and dry. The sand bar south of the old entrance serves the town for a cemetery. The basin behind is drained by the palmate branches of the Penetangore, which have all cut deep, young valleys in which they rush along over beds of stony waste. The lowest reach of the river serves, like Forel's plemyramêtre on Lake Geneva, to show the Lake or Harbor seiches, by alternate down and reversed flow of the river. Elevated beaches under bluffs in till occur on the lakeward side to the north and south.

The shore and the immense dunes in the southern region at Holland, Muskegon, Pentwater, or Ludington, are all of the finest sand, which only the strong west winds save from the lake as the land settles down. To the northward at Kincardine the rising of the land brings continuous new levels of the till into the play of the waves, which pick out pebbles and bowlders to line a beach on which sands make only patches, and where the dunes are of but moderate significance, since the sand supply is small. Petowsky, also north of the isobase, on Lake Michigan shows a similar beach.

Studies continued from Lynn, 1898, to Martha's Vineyard, 1901, show the beach cusps to be component features of a *beach ridge*, prominent on the tideless Great Lakes, and faint but recognizable on the ocean. Cusps are found at numerous points on the lakes, are always developed with abating surf or off-shore winds, with an interval that bears some proportion to the strength of the waves, often having three-foot spaces at Kincardine and eighty on the ocean. The ridge is often without cusps; has at times been seen and photographed with water caught behind and rushing out at breaks in the line, as with the weed line at Lynn; and at times grades from continuity to regions of perfect cusps. The cusps seem related to a long-shore current, their precise cause not being evident. The cross waves noted by Bramer, 1898, were seen habitually at every point, and photographed, but were not seen to be accompanied by cusps, nor were the numerous cusps observed and photographed seen to associate with such cross-waves.

Land and sea breezes were observed; the small deflagration wrought by blown sand on rock-material; and the small dimensions of Lake waves that seriously endangered shipping.

Valley Loess and the Fossil Man of Lansing, Kan. By WARREN UPHAM, St. Paul, Minn.

THE loess in the Missouri and Mississippi valleys is attributed to deposition by these rivers during a time of somewhat lower altitude of

this region, at the beginning of the Champlain epoch, when the glaciated area of this continent sank from its previously high elevation to be mostly 300 to 500 feet lower than now. By this depression a temperate climate was restored on the border of the continental ice-sheet, which became greatly reduced by its surface melting, so that much of the drift before contained within the ice was at last exposed on the thinned ice-fields, as now on the Malaspina ice-sheet in Alaska.

The ice-melting and rains probably swelled these great rivers to twice or three times their present average annual volume; and their supply of silt, brought in abundance by the rills, brooks, and rivers that flowed down from the waning ice-sheet, was very probably fivefold to tenfold more than now. Under these conditions of very abundant silt, rivers swollen to floods throughout the summers, and less current of their sluggish descent to the Gulf, it is estimated that the Iowan stage of chief deposition of the valley loess, gradually building up the river flood plains to heights of 150 to 250 feet above the bottom lands of today, may have occupied only about a thousand years.

During the same time the winds are thought to have blown away much of the loess from the valley flood plains, and from the ice surface, spreading it far and wide as the general sheet of upland loess, mostly 10 to 25 feet thick, mantling the high and low lands upon the great areas between the rivers with a surprising uniformity of thickness. It is evident, also, that this silt mantle includes some contribution, most considerable westward, of wind-borne dust from the great western plains, this part not being of glacial origin.

After the accumulation of the loess, and before the moraine-forming Wisconsin stage of the waning and wavering glaciation, this region was uplifted 300 to 500 feet, or perhaps somewhat more, on account of the diminution of the ice weight and pressure, thereby giving to the rivers the same steeper gradients and more powerful currents as now. They therefore eroded the valley loess to depths somewhat below the present bottom lands, and sculptured the valleys in nearly their present forms, with high inclosing bluffs of loess, before the moraines of Wisconsin, Minnesota, and northern Iowa, were amassed along the ice boundary at pauses of its general retreat.

Again, during this Wisconsin stage much modified drift was borne into the valleys. Its coarser portion of gravel and sand filled the valleys anew to heights of 100 to 200 feet, or more, near the ice border; but the strong river currents, with nearly their present slopes, carried the fine silt, corresponding to the former loess deposit, far down the valleys to the lower Mississippi and the Gulf.

Along the Big Sioux Valley, on the northwest boundary of Iowa, a flood plain of modified drift associated with the moraines has an average width of one and a half miles, as described in Vol. X of the Iowa Geological Survey, and is only about 10 feet above the present relatively insignificant bottom land, which averages about a fifth of a mile in width. Below the junction of the Big Sioux with the Missouri, this flood plain of Wisconsin time continues with a width of 6 to 12 miles on the east side of the Missouri through the distance of 90 miles to Council Bluffs and Omaha, having only the same slight altitude above the river. Southward from the mouth of the Platte river, as I think, the old Wisconsin flood-plain was lower than the bottomland today, which has gained in thickness, rather than lost, ever since the Ice age. Conditions requisite for silt deposition 30 to 50 feet above the Missouri at Lansing, Kan., where a skeleton was discovered last February under 20 feet of a deposit, which I regard as the original Iowan loess, appear thus not to have existed during the ensuing Wisconsin stage of glaciation, nor during any part of the Postglacial period.

The antiquity of the Lansing man is, I think, to be measured by about 12,000 years, or, at the longest, 15,000 years. But men are known to have been living in Europe, and very probably they may also have migrated to America, in the early part of the Ice age, or even before it, that is, very surely as long age as 100,000 years. Therefore the resemblance of the Lansing skeleton to the average type of our American aborigines, called Indians, appears in no degree surprising to one who believes that the creation of plants and animals has proceeded by the gradual methods of generic and specific development which are collectively termed evolution.

History of the Caribbean Islands from a Petrographic Point of View.

By Dr. Persifor Frazer.

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At the Bath meeting of the B. A. A. S. in 1888 I presented numerous rock specimens and thin sections cut from them illustrating a region of about forty miles around Santiago de Cuba. The rocks were partly eruptives and partly clastic, but almost all exhibited profound alteration. The thin sections from these eruptives were examined with me by Dr. Hensoldt, Mr. Kunz, and Mr. Lacroix in this country, and later by Mr. Teall, Mr. Rudler, the Abbé Renard, Professor Judd, and the lamented Professor George H. Williams in London; all of whom were practically agreed as to the main constituents.

The specimens were divided into:

A. Those from the hills containing the West mine of the Jurugua Iron Co. near Firmeza: (1) diorites, some of which contained much altered hornblende and viridite (chlorite), the thin slides filled with microlites and the rocks traversed by epidote veins; (2) dolerites (gabbros) with chloritic groundmass, magnetite, rods of feldspar, and some olivine.

B. From the hills southeast of that in which the East mine was located and about fifteen miles northeast of Santiago de Cuba: (1) garnet rocks with iron ore (sp. gravity 3.962); (2) fibrous actinolite and brown iron oxides partially altered to an epidotic mass; (3) iron ores (some showing cross lines like the Widmanstätten figures in meteoric iron).

C. From the Sietes Altarés, about thirty-five miles east of San-

tiago de Cuba: orthofelsite porphyry (rhyolites) like those erroneously referred to by the late Professor H. D. Rogers as "jasper," and later recognized by the late Dr. T. Sterry Hunt as a mixture to which he gave the general name "orthophyre," also like the Arvonian tuffs of Hicks near St. David's Head, Pembrokeshire, Wales.

D. The specimens from the region of the La Plata mines were quartzites containing hornblende, iron ores, and among the incidental minerals a claret-red garnet.

In the area described were found upon or associated with the eruptives sandstones, conglomerates and crystalline limestones, laminated iron ores with masses of pyrite not yet converted into the latter. The alteration of the areas of contact in these rocks by the more recent diorite dykes which cut them was evident.

From the zoölogical and geological researches of Alexander Agassiz in Caribbean and Mexican waters, and the careful studies by Gabb, Crosby, Spencer, and Hill, the probability of very great changes of level in the Antilles since the close of the Cretaceous period is fortified by several different lines of proof, *i. e.*, the ledges and shelves of the island borders, the wide distribution of the white radiolarian limestones, etc. Professor Crosby pointed out orographic reasons for assuming a former "bridge" (*i. e.*, causeway) between the greater and lesser Antilles. As he says, the mountains of "the northern arm of the island of San Domingo pointing toward Cape Maysi on Cuba," and the northern range in Cuba "regains the western trend and points directly toward Yucatan." He also alludes in his paper of December 13, 1882, to the "axis of old eruptive rocks," of which, so far as he has been able to learn, "each member of the group consists." He does not give his authority for the fact, nor say to what age he ascribes these eruptives; but if he contemplated the possibility of this age being pre-Cambrian, he anticipated by six years two of the strongest reasons I adduced for belief in the physical continuity of the great and little Antilles, and the present exposure of parts of the nucleus which are of great age and possibly have never been very deeply covered by sedimentary rocks.

His observation that this nucleus is flanked on either side by schists and slates I have confirmed, and I have been tempted to class these with the damourites of the Appalachians, and the feldspar porphyry (rhyolites), with the Arvonian tuffs of South Wales.

[1] *Zur Geologie von San Domingo.* Abh. der naturw. Gesel. "Isis" in Dresden, 1897, Heft II, p. 64).

It is gratifying to find that Dr. W. Bergt supports unreservedly the Archean age of the nucleal axes of the Caribbean islands in the following words:[1]

Das archäische Alter, welches, P. Frazer für die Centralketten des südöstlichen Cuba feststellen konnte, und das er für ganz Jamaika, für San Domingo, Puerto Rico, und die Windwardinseln vermuthete, kann nunmehr bestimmter für San Domingo angenommen werden.

It may be, as Mr. Hill suggests, that no "Paleozoic nucleal rocks" have been established with certainty in "Cuba and Santo Domingo" or any other of the border lands of the "American Mediterranean" (*Cuba and Porto Rico*, p. 384) although de Castro imagined he had discovered such near Cienfuegos, yet this fact would not invalidate the evidence that part of these nucleal rocks are pre-Cambrian.

And one purpose of this paper is to recall the fact that we have proofs of physical connection with the western continent of these outlying islands not only from the physiographic features, drowned valleys, submerged plateaus, trend of conformation through the major axes of the present detached islands, paleontological analogy with South American forms of life, etc., but, in addition to all these, the close petrographical relationships of the crystallized and crystalline rocks and their congeners with those of the main-land.

The island of Cuba seems to be constructed of an original igneous mass, diorite, on which clastic rocks, including mica-schists which may be Paleozoic, and sandstones and limestones of Mesozoic and recent ages, are deposited without apparent effects of metamorphism. Through all these are veins of newer eruptives which have generally altered the rocks they have fissured, *i. e.*, giving crystalline character to the radiolarian limestones lifted since Cretaceous time out of the adjacent seas, producing magnetite in the iron-oxides derived in part from the pyrite, changing to quartzites the siliceous slates, etc.

The lithological character, great alteration, complexity of the series, analogies in paragenesis and alteration-products with rocks of Archean areas in various distant parts of the earth's surface, and the physiographic relations of the greater and lesser Antilles to the peninsula of Yucatan and to Venezuela, suggest a physical connection with the South American continent, and a former American Mediterranean (Caribbean) sea.

These conclusions are in harmony with those of Professor Crosby, Professor J. W. Spencer, and Mr. R. T. Hill, and are specifically confirmed by Dr. Bergt (*supra*). They constitute a reinforcement of the

results arrived at by geotectonal, through petrographic, considerations, in the attempt to retrace the geological history of the West Indies.

A paper received December 27, from Dr. Callaway presents in the description of the structure of the island of Anglesey a remarkable parallel with that of the island of Cuba.[1]

Some Results of the Late Minnesota Geological Survey. By N. H. WINCHELL.

THIS paper mentioned some of the scientific conclusions and some of the known economic results reached by the survey, presented in the final report. Among the scientific conclusions have been: the definition of the parts of the Upper Cambrian in the upper Mississippi valley; the identification of the Potsdam sandstone as seen at Potsdam, N. Y., with a quartzitic sandstone which was found to be a part of the Keweenawan; the definition of the Lower Silurian and its parts; the determination of the eastern extent of the Cretaceous; the discovery and announcement of the duality of the ice-epochs; the determination of the length of time elapsed since the last (or Wisconsin) ice-epoch, through the recession of the falls of St. Anthony; the formation of glacial lakes about the ice-border; the origin of kames (now called eskers) in ice-walled gorges; the superglacial position of the drift while being transported, especially in proximity to the ice-margin; the duality of the iron-bearing formations in the Lake Superior region, and the later discovery of a third horizon; the separation of the Archean *en masse* into two non-conformable parts, viz., the upper and the lower Keewatin, with a great basal conglomerate between them; the detection of the oldest known rock in the Lake Superior region (the greenstones called *Kawishiwin*), the supposed earliest crust of the globe; the origin of the Mesabi ores in a greensand which has been altered, affording iron oxide by concentration; the contemporary deposition of oceanic silica from solution; the original greensand, and pebbles and breccia associated with it, as well as sheets of basic lava of the same date, were of volcanic origin; the well-known jaspilytes of both Mesabi and Vermilion ranges were originally the result of silification of volcanic obsidian (supplementary to the hypothesis of Wadsworth), but sometimes were broken and distributed so as to constitute secondary jaspilyte beds; the formation of

[1] "Plutonic complex of Central Anglesey," *Quarterly Journal of the Geological Society*, Vol. LVIII (November, 1902).

sedimentary jaspilyte from the chemical precipitation of silica, this grading into other sedimentary rocks; the derivation of the granites of the Archean from metamorphism and fusion of Archean sediments; the supposed origin of the alkaline quality of these first sediments being in the atmosphere, as the basal crust could not have afforded them; the derivation, in the same manner, of the gabbro and associated basic igneous rocks, from the metamorphism and fusion of the greenstones with their clastic variations; the addition of a large number of minerals to the known mineralogy of Minnesota.

Of economic and educational results the following were mentioned: the discovery of the cause of foul water in common wells in the prairie region of Minnesota, and the suggestion of effective remedies; the discovery, through a series of physical tests, of the excellence of the Hinckley sandstone, now widely used under the name "Kettle River stone." The existence and position of the Mesabi range, as distinct from the Vermilion range, was pointed out in 1884. This was followed by explorations which resulted in the first discovery of important bodies of ore on that range.

"But notwithstanding the scientific discoveries of the Minnesota survey, and over and above all its aid rendered to economic interests, it is probable that the most valuable service it has rendered to geology consists in this: The illustration it has given of the establishment of a state geological survey by the state legislature and the intrusting of the same to the state's university. It is not an uncommon thing now, but when the Minnesota survey was submitted to the board of regents of the state university, it was a novel and unheard-of proceeding, and its progress was scrutinized closely by the authorities of other states. The original law was carried out without a single change. The plan of progress and of the report which was adopted the first year of the survey was faithfully carried out to completion and without a single interruption, lasting a period of twenty-eight years, *i. e.*, from 1872 to 1900."